Before The
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Mobile Satellite Service in the 1610-1626.5 MHz and 2483.5-2500 MHz Frequency Bands	CC Docket No. 92-166

TECHNICAL APPENDIX

TO COMMENTS OF

LORAL/QUALCOMM PARTNERSHIP, L.P.

Volume II of II
(Attachment 12)

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OFFICE OF SECRETARY

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ATTACHMENT 12

COMSEARCH

An Alliance Telecommunications Company

GLOBALSTAR

FEEDERLINK SPECTRUM SHARING STUDY

Prepared for

LORAL QUALCOMM SATELLITE SERVICES, INC.

May 2, 1994

Comsearch • 11720 Sunrise Valley Drive • Reston, Virginia 22091 • (703) 620-6300

COMSEARCH

EXECUTIVE SUMMARY

Several frequency bands were analyzed by Comsearch in order to evaluate the feasibility of sharing between existing services and Globalstar's feederlink-satellite communications. The following bands were analyzed for the downlink portion: 6425-6525 MHz, 6525-6875 MHz, 6875-7125 MHz, and 12.75 - 13.25 GHz. The uplink bands analyzed were: 6525-6875 MHz, 10.70 - 10.95 GHz, and 11.20 - 11.45 GHz.

The followed approach included studying the interference impact from the Globalstar relevant subsystems on existing terrestrial systems in selected geographical areas. The geographical areas' contours were circles with a 120 mile radii centered in major US cities. Comsearch proprietary databases were used to provide the necessary data. The selected data sets showed sufficient variation in antennas, modulation types, elevation angles, and fade margins. For the Auxiliary Broadcast electronic news gathering (ENG) and other TV pick-up operations, research was done to deduce typical systems' parameters.

The interference calculations were based on worst case scenarios. The satellite was always assumed to lie within the terrestrial antenna's main beam. The feederlink antenna did not assume elevation angles greater than 10 degrees, and assumed an azimuth range between 0 and 360 degrees. Upon calculating the predicted interference from a Globalstar satellite or a feederlink, the predicted values were compared to the interference objectives. The interference objectives for the downlink portion were based on the latest Electronic Industries Association's developments and standards. For digital radios, manufacturers' interference specifications were used. The uplink portion followed current FCC criteria in the equivalent common carrier bands.

Downlink sharing analysis with the Private-Operational Fixed Service (OFS) in the 6525 - 6875 MHz frequency band, were conducted for Salt Lake City, Washington DC, Chicago, San Mateo, and New Orleans. The results showed that 88.2 percent of the studied cases pass the interference criteria, while 11.8 percent require further refined computations over the worst case analysis conducted. The 6425 - 6525 MHz frequency band records were part of the analysis given in the 6525 - 6875 MHz frequency band, other than TV pick-up and ENG type operations.

The downlink studies in the 6875 - 7125 MHz frequency band were conducted for Columbus, Washington DC, Chicago, San Mateo, and New Orleans. The studies showed that 99.7 percent of the analyzed cases pass the short haul interference criteria, while 97.8 percent passed the long term interference criteria. The remaining cases, 0.3 percent of the total, did not pass the short haul criteria. The long haul remaining cases were 2.3 percent of the total. All remaining cases require further refined computations over the worst case analysis conducted. Four common ENG configurations were analyzed in the 6875 - 7125 MHz frequency band. Under complete fading conditions, all four configurations maintained acceptable performance with the presence of a Globalstar satellite.

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The 12.75 to 13.25 GHz downlink studies were conducted for Tampa, Washington, DC, Chicago, San Mateo, and New Orleans, The analyses showed that the majority of the cases passing the short haul objectives. The few remaining cases require further refined computations. One ENG configuration was studied in this band. Under complete fading conditions, this configuration will maintain acceptable performance with the presence of a Globalstar satellite.

Overall, the downlink analyzed frequency bands reflect a reasonable expectation for sharing. With sound frequency coordination practices, similar to those existing today, and more detailed interference prediction involving the mobile satellites' exact position and the relevant interference duration, sharing may very well be possible. The improvement in interference prediction should limit overly protected cases, and should facilitate frequency planning.

The uplink studies in the 6525 - 6875 MHz, the 10.7 - 10.95 GHz, and the 11.2 - 11.45 GHz frequency bands, were conducted for two sites: Staten Island, NY, and Rapid City, South Dakota. The analysis showed considerably higher number of terrestrial paths in both frequency bands for Staten Island.
In the 6525 - 6875 MHz, 85.2 percent of the analyzed cases pass the interference objective at Staten Island , while 80 percent of the analyzed cases pass the same objective at Rapid City.

In the 11 GHz bands, 90 percent of the cases pass the interference objective at Staten Island, while 100 percent of the cases pass the same objective at Rapid City. For both analyses, in both bands, over-the-horizon-loss, and a 15 dB shielding factor were utilized to reduce the number of cases. The remaining cases require further detailed computations including the variation of the feederlink antenna's elevation angle beyond 10 degrees, thus reducing the expected power towards the horizon. The improved analysis should also include fixing the azimuth planes at the feederlink so that more directivity could be incorporated for the terrestrial antennas. These improved analyses should reduce remaining cases, and facilitate the frequency coordination process.

The uplink studies show a heavy dependence on the selected site's attributes. Terrestrial congested areas should be avoided. In general, with sound site selection, proper coordination practices, and further improved interference prediction calculations involving the interference duration and the instantaneous position of the feederlink antennas, sharing may very well be possible.

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ENG Not Summarized

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MAIN REPORT

1.0 Introduction

1.1 General

This feasibility report provides the methodology, analyses and results of Comsearch's investigation into the possibility of the Globalstar low-earth-orbit feederlinks sharing frequency spectrum with existing fixed microwave services operationing in the United States.

The frequency bands considered for the downlink to the feeder earth station include:

- 6525 to 6875 MHz
- 6875 to 7125 MHz
- 12750 to 13250 MHz

The frequency bands considered for the uplink from the feeder earth station include:

- 6525 to 6725 MHz
- 10.7 to 10.95 GHz and 11.20 to 11.45 GHz

The main body of the report provides the basis for the study, the methodology, the derivation of the interference objectives, the calculations of potential interference and summarizes results and the conclusions reached from the analysis conducted in each band of interest.

The individual bands analyzed are documented in the Appendices as follows:

Appendix A: Downlink in Operational-Fixed Microwave Band (6525 to 6875 MHz).

Appendix B: Downlink in Auxiliary Broadcast Band (6875 to 7125 MHz).

Appendix C: Downlink in Cable Television Relay Service (CARS)/Auxiliary Broadcast Band (12750 to 13250 MHz).

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Appendix E: Uplink in Operational-Fixed Microwave Band (6525 to 6875 MHz).

Appendix F: Uplink in Common Carrier Band

(10.7 to 10.95 GHz and 11.20 to 11.45 GHz)

1.2 Basis for Analysis

The basis are given separately for the downlink and uplink analyses.

1.2.1 Downlink Frequency Bands

For the downlink analysis, the following criteria were used in the analysis.

- Site locations were selected in congested terrestrial microwave areas with varying terrain features and different climate-zones. This ensures that a significant number of paths with a diverse variation of operational parameters are considered in areas with varying Radio Frequency (RF) propagation characteristics.

- Once the site locations were established, a geographic boundary was defined as a 120 mile square area centered at the city's reference coordinates (as listed in FCC Rule Part 76.53). All microwave paths operating within this boundary are considered in this analysis.

- The power flux density (PFD) of a Globalstar satellite signal varies as shown in Table 1.2.1-1 from a minimum of -173.5 $dBW/m^2/4$ kHz to a maximum of -164.5 $dBW/m^2/4$ kHz.

Elevation	PFD (dWB/m^2/4 kHz)
0	-173.5
5	-171.5
10	-169.5
15	-168.5
20	-166.5
25	-165.5
30	-164.5
40	-164.5
50	-164.5
60	-164.5
70	-164.5
80	-164.5
90	-164.5
The PFD has over a 3 dB margin for uneven loading	

TABLE 1.2.1-1
Globalstar
C-Band Power Flux Density (PFD)

- The tilt or elevation angle of a terrestrial receive antenna was calculated. The tilt angle was then used to determine the applicable satellite's power flux density, PFD. When the terrestrial antenna is pointing downward, -173.5 dBW/m^2/4 kHz and the main beam gain was applied.

- When the terrestrial antenna is pointing within 0 and 90 degrees, the PFD was evaluated at the terrestrial antenna tilt angle. If the tilt angle is not given by Table 1.2.1-1, logarithmic interpolation between the closest two points was used for 0-90 degrees tilt angles, the antenna vertical gain pattern was assumed (based on geometrical symmetry) to be same as the horizontal gain pattern. The gain pattern was determined to decrease much faster than the increase in the PFD as we move away from the antenna tilt angle. Thus, the main beam coupling constituted the largest resultant interference power.

- When a terrestrial receive station utilizes a periscope antenna system (consisting of a billboard reflector mounted above ground level which reflects the desired signal toward the ground where a parabolic antenna is pointed straight upward), the LEO satellite signal level was calculated twice. The first method determines the satellite signal level into the terrestrial receiver when the satellite passes the horizon and illuminates the billboard at a PFD of approximately -173.5 $dBW/m^2/4$ kHz. The second method determines the interfering carrier level when the satellite passes directly above the parabolic antenna that is pointed straight upward. Both interfering carrier levels were then compared to the appropriate interference objective to determine if the satellite signal level would satisfy the objective in both worst-case interference scenarios.

- For terrestrial systems utilizing billboard reflectors as passive repeaters, if the predicted LEO satellite signal level fails to meet or satisfies the prescribed interference criteria at the repeater location it is assumed that the criteria would continue to be missed or satisfied at the final receive station.

- This analysis utilizes the fact that a terrestrial microwave antenna will only be main beam illuminated by one Globalstar satellite at a time.

- The bandwidth of the terrestrial receiver is based upon typical receive filter bandwidths currently operating in the appropriate frequency bands and varies depending upon the transmitter's modulation. The following receiver bandwidths were used.

  - Analog (FDM/FM) systems, twice the emission bandwidth of the transmitter.

  - Digital Systems, 1.5 times the emission bandwidth.

  - Video Systems (AM and FM) the receiver's bandwidth is equal to the transmitter's bandwidth.

- The Globalstar satellite downlink signal consists of 13-1.23 MHz bandwidth signals occupying a 16.5 MHz bandwidth channel with 8 left hand circular polarized (LHCP) channels and 8 right hand circular polarized channels (RHCP) utilizing approximately 200 MHz of bandwidth.

- The critical angle for determining the interfering signal level into a terrestrial receive antenna from a LEO satellite is in the vertical plane. Since the vertical radiation patterns of terrestrial microwave antennas are not usually available from the antenna manufacturers, the following assumption is used in our analysis. It is assumed that due to the geometric symmetry of terrestrial parabolic antennas, the radiation pattern in the vertical plane (perpendicular to the ground) is equivalent to the radiation pattern in the horizontal plane.

- Interference analysis is based on co-channel interference objectives.
- No geographic or man-made obstruction is assumed to exist between the terrestrial microwave antenna and the proposed LEO satellite.
- Currently applied for and deployed microwave systems were analyzed.
- The interference objective were primarily based on the Electronic Industries Association's standards.
- The utilized power spectral density is a uniform square density based on -164.5 dBW/4 kHz and a bandwidth of 16.5 MHz. For interference into digital receivers greater in bandwidth than 16.5 MHz, the power spectral density bandwidth was assumed infinite.

1.2.2 Uplink Frequency Bands

For the uplink frequency bands the following parameters were used in the analysis.

- Maximum Globalstar uplink power density into the antenna is -7.0 dBW/4kHz.
- The earth station antenna pattern conforms to 32-25logθ towards the horizon. This is the pattern used in the frequency coordination with terrestrial users as stated in Code of Federal Regulation 47 Part 25 Section 25.251(c)(4).
- Based on a minimum elevation angle to the low-earth-orbit satellite of 10 degrees an antenna discrimination angle equal to the elevation angle was selected to determine the earth station antenna gain towards the horizon of 7 dB (32 - 25 log10).
- The maximum power flux density from the earth station towards the horizon is 0 dBW/4kHz (-7 dBW/4 kHz + 7 dB).
- The proposed 3.4 meter antenna has a main beam gain of 45.4 dBi at 6.7 GHz.
- The antenna has a beamwidth of 0.8 degrees and 1.6 degrees at the 3 dB and 15 dB points respectively.
- The satellite arc considered was from 0 to 360 degrees with the minimum elevation angle of 10 degrees in all directions.
- The interference objective is -154 dBW/4 kHz for 20 percent of the time at 6.7 GHz. At 11 GHz -151 dBW/4 kHz for 20 percent of the time was used. This is based on the current procedures followed to coordinate geostationary earth stations which comply with Part 25 of the FCC rules.
- A coordination contour distance with a 250 kilometers radius was selected. All terrestrial microwave receivers within this contour were analyzed. The 250 km distance corresponds to the maximum coordination distance for a geostationary earth station operating with a minimum elevation angle of 10 degrees and with similar parameters as a LEO feederlink.
- Only great circle interference (GC) conflicts were considered in this report.
- The orbital mechanics and the relationship to the amount of time the earth station main beam is in the direction of the satellite were not considered.